

Project Commitment Document

Checkout and Launch Control Systems (CLCS)

84K00009

It is the responsibility of each of the signing party to notify the other in the event that a commitment cannot be met, and to initiate a timely renegotiation of the terms of this agreement

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PROJECT COMMITMENT DOCUMENT

CHECKOUT AND LAUNCH CONTROL SYSTEMS (CLCS)

1. PROJECT NEED STATEMENT

The need for an automated launch processing system at Kennedy Space Center (KSC) evolved from the Shuttle Transportation System (STS) requirements that included the need for rapid launch turnaround to meet the projected launch rate and program economic objectives. In June 1972, after analysis of Shuttle processing requirements, the Launch Processing System (LPS) concept, which led to the present LPS configuration, was baselined. Design of LPS was completed in 1976 followed by Firing Room integration and applications software development.

KSC has successfully used LPS since the early 1980s for the Shuttle operations. However, the system lacks modern computing capabilities, uses an archaic custom programming language, and requires numerous patch-in, subsystem add-ons to maintain its capabilities with changing mission requirements.

The current Launch Processing System (LPS) supporting the Shuttle Program is 1970's technology. It suffers from reliability and obsolescence problems and has serious expansion limitations. The Checkout and Launch Control System (CLCS) will replace the current Launch Processing System (LPS) with state-of-the-art technology and redefine processes established based on old technology.

“CLCS represents NASA's investment in the future which will ensure continued safe and dependable Shuttle launch support for the duration of the Shuttle Program, reduce Shuttle operational costs, and provide building blocks for future endeavors”

2. PROJECT OVERVIEW

2.1 PROJECT OBJECTIVE

In parallel with the *NASA Strategic Management Handbook* to do things better and for less cost, CLCS is more than a replacement of 20+ year old hardware to reduce Operations and Maintenance (O&M) costs and obsolescence problems. The primary goal of the CLCS project is to redefine the Space Shuttle processing environment to improve checkout efficiencies. The CLCS Project will require complete review of the functional requirements of hardware, system software and end user application software. This includes a thorough examination of our culture and the way in which we are accustomed to processing vehicles and payloads. The preliminary analysis phase has already identified several key areas where operational efficiencies can be achieved, changes to today's process that cannot be readily implemented due to the limitations of the existing hardware. As the Shuttle Program

embraces “change for efficiency”, CLCS will provide an adaptable platform to implement critical and necessary process enhancements, as well as provide the ability to support Shuttle upgrades and future advanced launch systems.

As the *NASA Strategic Management Handbook* also stresses the communication, sharing, and transfer of information, CLCS merges the multiple data sources in existence today into one central data resource which can easily be distributed to other NASA centers and beyond. This capability will support the fulfillment of NASA’s goal to enhance the Space Operations Services to its customers during the mission preparation and launch phases.

The CLCS Project follows many of the “Critical Success Factors” as defined in *The Strategic Plan for NASA’s Enterprise for the Human Exploration and Development of Space*. These include:

- Decreasing Space Shuttle costs and improving the management and operations of the integrated government/contractor team;
- Achieving dramatic reductions in the cost of space flight;
- Maintaining a skilled and motivated workforce;
- Maintaining high ethical practices and respecting the human and civil rights of our workforce and our partners.

The replacement of LPS with CLCS will resolve the current reliability and obsolescence problems and will provide a platform to preclude future obsolescence issues. The CLCS concept also moves away from processes invented based on 1970s technology and takes full advantage of modern Commercial Off the Shelf (COTS) Equipment. This improved system reliability, flexibility, and supportability will significantly reduce O&M costs. By keeping pace with today’s technology, improvements in Shuttle data availability and distribution will be achieved.

2.2 TECHNICAL DESCRIPTION

2.2.1 Requirements

CLCS is required to replace the functionality of the existing Launch Processing System which is an integrated network of computers, data links, displays, controls, hardware interface devices, and computer software required to control and monitor flight systems, ground support equipment (GSE), and facilities used in direct support of Shuttle vehicle activities. Although O&M of the Hardware Interface Modules (HIMs) will eventually fall under the O&M tasks of CLCS, the replacement of the HIMs is not part of the CLCS effort as they are currently being replaced as a separate effort.

CLCS is required to replace the functionality of LPS sets currently located in:

- | | |
|------------------------------------|--|
| 1) Firing Room One | 2) Firing Room Two |
| 3) Control Room Three | 4) Control Room Four |
| 5) Complex Control Set | 6) Hypergolic Maint. Facility |
| 7) Cargo Integrated Test Equipment | 8) Shuttle Avionics Integration Laboratory |

9) Dryden Flight Research Center

10) Processing Control Center

Although CLCS is replacing an existing system where requirements are well defined, the CLCS team will work diligently to challenge and separate real requirements from 20 years of cultural influences, thus minimizing the complexity of design, ensuring that COTS products can be implemented into the CLCS design, and allowing for greater flexibility and creativity in the fulfillment of the “real requirements”.

Involvement of the user community is critical to the success of the CLCS project and therefore this involvement will be part of each phase of each incremental delivery. The user community is responsible for developing, approving, and performing the test plans for the verification, validation, and certification of CLCS.

CLCS will also redefine the Space Shuttle processing environment in several key areas which will improve checkout efficiencies:

- Command and monitor data paths will be separated
- Monitor data will be distributed freely without fear of inadvertent command issuance
- Launch team members will be able to view test, playback, or simulated data in their office environment
- Test engineers will be able to monitor and control multiple systems from a single console
- Each Operations Control Room (OCR) will be capable of being divided into multiple ‘Flow Zones’ as needs dictate; each linked to a different Orbiter under test
- Multiple Orbiters located in any facility (Orbiter Processing Facility (OPF), Vehicle Assembly Building (VAB), Pad) will be capable of being controlled from a single OCR
- Only three control rooms will be required (one existing control room will be eliminated as CLCS is deployed)
- Consolidation of data:
 - Data currently residing across multiple platforms (Checkout Control and Monitor Subsystem (CCMS), Record and Playback Subsystem (RPS), Central Data Subsystem (CDS)) will be integrated into the Shuttle Data Center (SDC)
 - Common interfaces to a variety of data sources, such as acoustic data, hazardous gas detection data, etc. will be provided to the test engineer at his console
- Integration of complex/facility control
 - Control of facility systems will be moved into the vehicle control rooms
 - The Complex Control Set (CCS) will be eliminated
- Implementation of Local Commanding Operations
 - The system will allow commanding from specific controlled areas outside the OCRs as enabled by Test Conductors
 - Subsystem re-test will be able to be performed locally at the test end item with minimal control room support
- Program compatible data
 - CLCS uses data formats and protocols compatible with other NASA Centers
 - Manned space flight centers can share data and more easily compare information
- Support future vehicles

- CLCS uses a flexible architecture that can easily and economically be adapted to support other/future vehicles
- The use of COTS equipment and software ensure that CLCS will be a cost effective solution to future economical vehicle processing

2.2.2 Systems Overview

There are several underlying principles that have shaped the architectural definition of CLCS. Together, these principles will improve the operational benefits of CLCS while decreasing the long term cost to the Shuttle Program.

Leveraged Solution: Reduce the cost of CLCS implementation by leveraging off other existing work. This includes applicable work from KSC and other NASA centers; COTS hardware, operating systems, languages and tools; and standards ranging from ISO to ANSI to ad hoc. This represents a savings in both development and maintenance costs.

Scaleable Distributed Architecture: CLCS is based on a distributed architecture that can be scaled by increasing the capacity on a box by box level rather than having to replace the entire system. Maximum data rates across the system were determined. Each box will be sized to handle this maximum load in order to ensure adequate performance during peak demands.

Message Based Rather Than Storage Based: Reliable messages, rather than a common system wide data store, have been chosen as the glue that binds the system together. Reliable messaging is a well understood approach for building distributed systems and is available as a COTS solution via multiple technologies. It simplifies redundancy management within CLCS sets and increases the fidelity and quality of End Item monitoring and control.

Improved Fault Tolerance: Fault tolerance and redundancy management is extended to cover End Item user applications. It is these applications that provide safe and effective control of the Space Shuttle and GSE. As a minimum fail-safe operation will be supported. Additional fail-operational support will be provided where practical.

Consolidated Data: In addition to the present data links supported by LPS today, CLCS will consolidate data from a number of other links that provide End Item test relevant information. This will enhance the information available to control room operational personnel to aid in making informed decisions.

Reliable Data: CLCS provides substantial improvement in the delivery of reliable End Item data to users and user applications. The improvements are data health, reliable data delivery, and complete data delivery. **Data health** information is provided for each Function Designator (FD) or measurement update allowing it to be tested for usability directly. Data health factors in Gateway status for the FD, knowledge of the FD's data path's health, and input from engineering. **Reliable data delivery** ensures that each concentrated FD update message is received resulting in no missing blocks of FD updates. FD update messages occur at a fixed periodic rate to each subscribing computer and are numbered. If a subscribing computer misses a message, retransmission can be requested. **Complete data delivery**

ensures that an application can process all data changes for selected FD's, not just the values that existed when an application reads them. FD updates, including time of change and health, will be queued for the application and can be processed as required by the user application.

Transforming Data into Information: The individual measurement FD's from each End Item Line Replaceable Unit (LRU) provide data about the LRU but not usually any directly usable information. *Data fusion* combines values of multiple FD's with good data health to determine state of an LRU or other summary information to form a new FD that can be tested directly. As an example, data fusion FD can be use for the OPEN/CLOSED state of a valve or the ON/OFF state of Orbiter power. Use of data fusion FD's greatly simplifies user application development and data retrieval.

Increased Availability: Numerous features within CLCS extend the availability and level of service. Additional control room personnel such as test directors, and remote personnel such as engineering in test/work areas can join into CLCS testing through built in access safeguards using dedicated and portable workstations. The logging of consolidated data makes test information more available to all CLCS users.

Layered Applications: Applications software in CLCS is provided by a minimal number of focused layered tools. This reduces the amount of application program development required and makes them more understandable. Layering allows actions to be defined and tested once and used repeatedly. As an example data health and data fusion permits the logic of coming up with the state of an LRU to be defined once. It can be reused with confidence by many application programs, user displays, and data retrievals for years to come.

Improved End Item Monitoring: Any user or user application can place a *constraint* against any FD requesting notification should the constraint be violated. Constraint monitoring and exception notification is performed by CLCS system software at data rate speed thus allowing every sample of data to be screened. Both standard and fusion FD's can be monitored. This permits End Items to be monitored with far greater resolution and reliability. Constraint examples include: a Test Application Script requesting all OMRSD requirements be monitored and reported for each system; a Test Application Script requesting Launch Commit Criteria be monitored for Ground Launch Sequencer (GLS); and a system's End Item Managers requesting that any deviations from the current commanded system state be reported.

CLCS will perform test, checkout, control, and launch of the Space Shuttle with advanced state-of-the-art technology. It will be the real-time hub of the KSC Shuttle Data Center and will communicate to the User regarding the status of Shuttle processing and launch countdown operations. An overall system-level block diagram is presented in Figure 2.2.2-1.

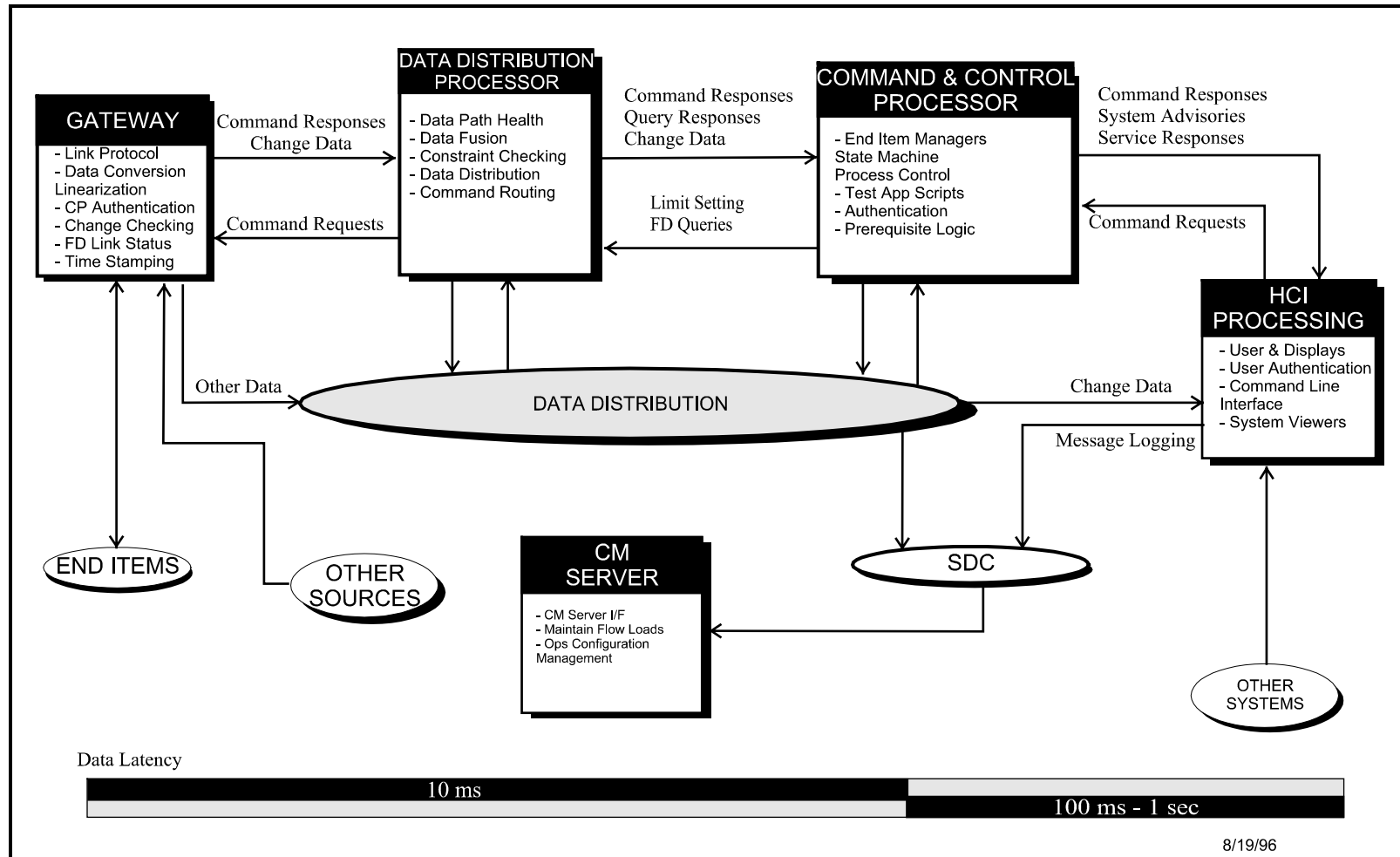


Figure 2.2.2-1 CLCS System-Level Block Diagram

2.2.2.1 Hardware Architecture

One of the driving forces behind replacing the existing CCMS is a desire to move away from custom-built, single-vendor-supplied, hardware onto COTS systems. The CLCS architecture is based upon COTS equipment with a few minor exceptions which are all considered to be extremely low-risk development items (keyboard switches, etc.).

CLCS is divided into three sections: a Front End Zone (FEZ) that contains the data acquisition equipment and other interface devices; a Control Zone (CZ) that contains the compute engines; and a Flow Zone (FZ) that contains the user workstations. These are illustrated in Figure 2.2.2.1-1. The FEZ and CZ are connected by a Real-Time Critical Network (RTCN), while the CZ and FZ are connected by a Display and Control Network (DCN).

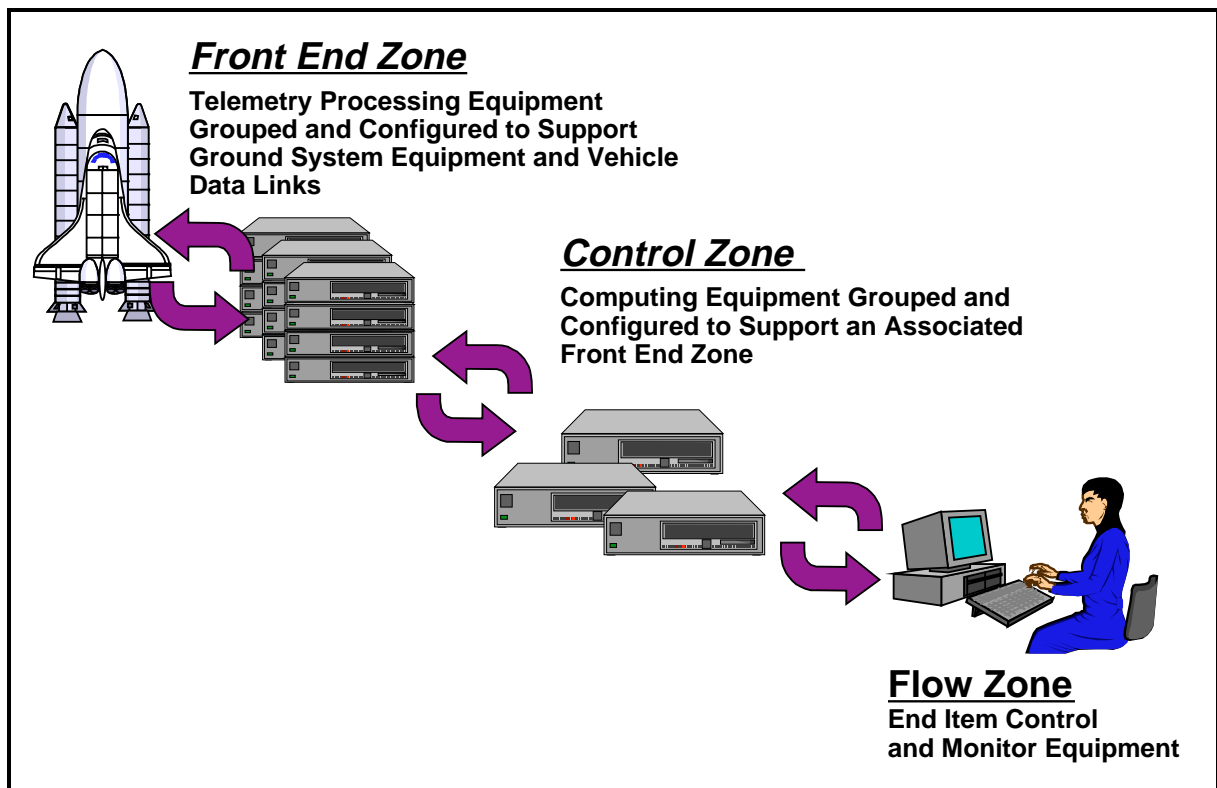


Figure 2.2.2.1-1 CLCS Equipment Zones

2.2.2.2 Software Architecture

A layered software architecture will be employed to improve safety, reliability, and quality. The system will deliver a higher level of knowledge than previously possible by including additional data, health, and status in the decision process. Vehicle configuration from other data bases (e.g., electrical connectivity) along with more complete definitions of valid system states will be combined to determine the actual end-item status. This final status will be much more reliable since all pertinent parameters are entered into the calculation.

In addition to improved reliability, a new constraint manager will enhance the sophistication of system control. This new constraint manager will provide surveillance over existing processes to enable appropriate action to be taken for system failures or unplanned excursions. All data samples of all pertinent data throughout the test will be utilized in lieu of selected or spot checks. The constraint manager will ensure that when a test is completed it met all the necessary criteria for successful completion. Discrepancies will be reported and handled prior to test completion.

System Software layering is shown in Figure 2.2.2.2-1. The Operating System will be COTS. System Services provide the foundation for system development. System Services include communication, data management, timing, logging, security, and network services. Application Services are the COTS and Custom tools, drivers, and special interfaces which support Application Software.

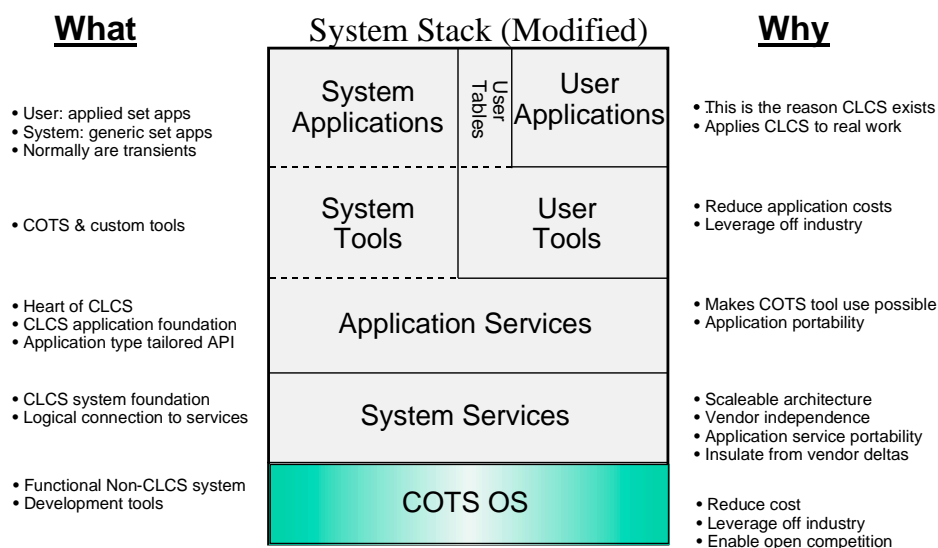


Figure 2.2.2.2-1 System Software Stack

Two types of applications will be supported, System and User Applications. System Applications are the applications that provide a service to multiple platforms. They include system utilities and productivity tools. User Applications are the applications which perform end item test, checkout, control, and monitor. The User Applications are tailored to support System Engineer Operators (one of the customers). User Applications provide user access and visibility.

The figure shows the capabilities at each layer, built upon the layer below it. Also shown is the functionality contained in each layer.

The Application Software Organization and Stack is shown in Figure 2.2.2.2-2 and 2.2.2.2-3. The System Engineer Operator must have reliable monitor information available at all times as well as positive control over the end item under test. These primary functions of Launch Processing, control and monitoring, shown on the top application software layer are designed to meet the needs of the System Engineer Operator. A layered application concept will be employed to provide a safe and reliable processing system. The layered approach will also reduce the amount of ad hoc code. Functions needed by multiple applications will only have to be done once.

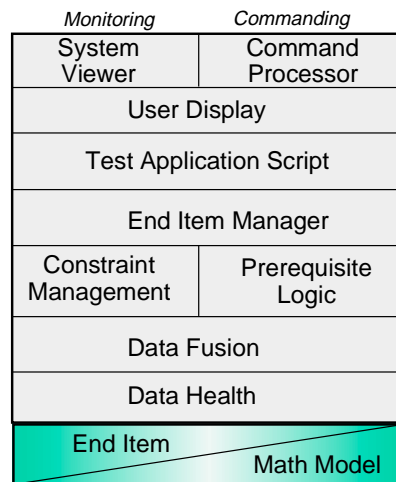


Figure 2.2.2.2-2 Application Organization

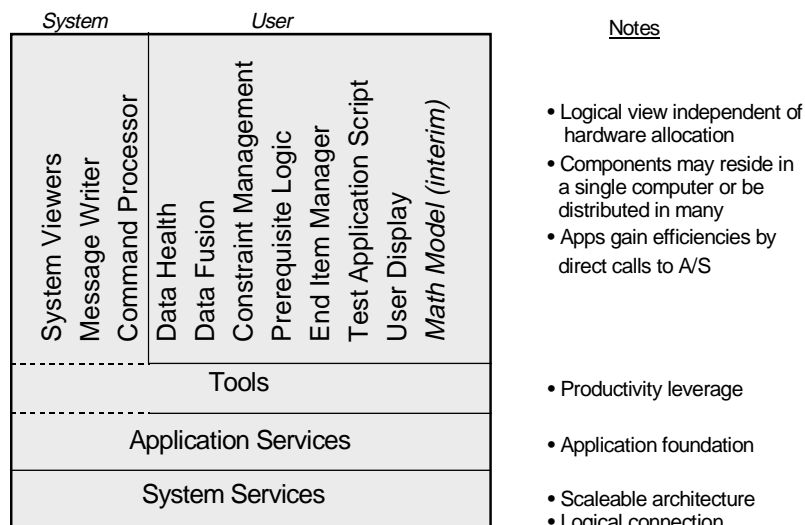


Figure 2.2.2.2-3 Application Stack

This approach will greatly simplify the overall system. Definitions for each layer follow:

Data Health: the reliability component of system and end item control. This includes communication path, data integrity, and component validity.

Data Fusion: the consolidation of all the attributes of the definition of a system state. For example, the state of a valve (open or closed) would be based upon commanded state, open and closed measurements, electrical connectivity, and system health.

Prerequisite Logic: the preliminary logic that must be satisfied prior to issuing safety critical commands. This is similar to current prerequisite logic, but will reside closer to the end item.

Constraints: the restrictions (e.g., end item control limits) that must be satisfied prior to completing a step in a sequence. Constraints are asserted and released to the Constraint Manager by other processes (User, End Item Managers, Test Application Scripts).

End Item Managers: the object oriented state based or process control application which controls and monitors test end items (e.g. Ground Support Equipment and Shuttle Vehicle Subsystems). An End Item Manager can receive notification from the Constraint Manager or a request from a user display, Test Application Script, or another End Item Manager. Reactive Control Logic procedures are End Item Managers with high (pre-emptive) priority.

Test Application Scripts: the sequence of events, or control procedure. It supports requests to End Item Managers, assertion/release of constraints to the Constraint Manager, prompting for manual steps to be performed, and requests to execute other Test Application Scripts.

Subsystem Displays: the display associated with a hardware end item. The display may be monitor only or may issue a request to an End Item Manager or Test Application Script for command and control.

System Viewers: a set of utilities which provide a standard viewer to display information on FD status, Test Application Scripts, constraints, data fusion, data health, and system configuration.

Command Processor: the command/control application or interface.

2.2.3 Impacts to Enterprises

CLCS is required to be compatible with and pose no impact to existing flight elements and GSE. A review will be conducted prior to the first complete CLCS Shuttle processing flow, to provide this assurance.

2.2.4 Related Documents (Technical)

Additional CLCS technical information, specifications, and requirements can be found in:

- NLPS Management and Technical Volume, Project Baseline
- 84K00051 Project Plan, CLCS
- 84K00200 System Level Specification, CLCS

3. ORGANIZATION AND ORGANIZATIONAL RESPONSIBILITIES

CLCS is a KSC NASA-managed activity, with contractor support from existing NASA contracts; the Space Flight Operations Contract (SFOC), the Mission Support Contract (MSC), the Engineering Support Contract (ESC), the Base Operations Contract (BOC), and the Payload Ground Operations Contract (PGOC). Using these existing multiple contracts to support the project provides flexibility which enables the project's management to capitalize on a wide range of available skills, experience which is critical to the project's success. The main intent here is to have the customer involved in the project throughout its life-cycle and to take advantage of technology and information transfer from other recent related technology upgrade activities.

Figure 3-1 illustrates the CLCS organization and its relationship to the Shuttle Program.

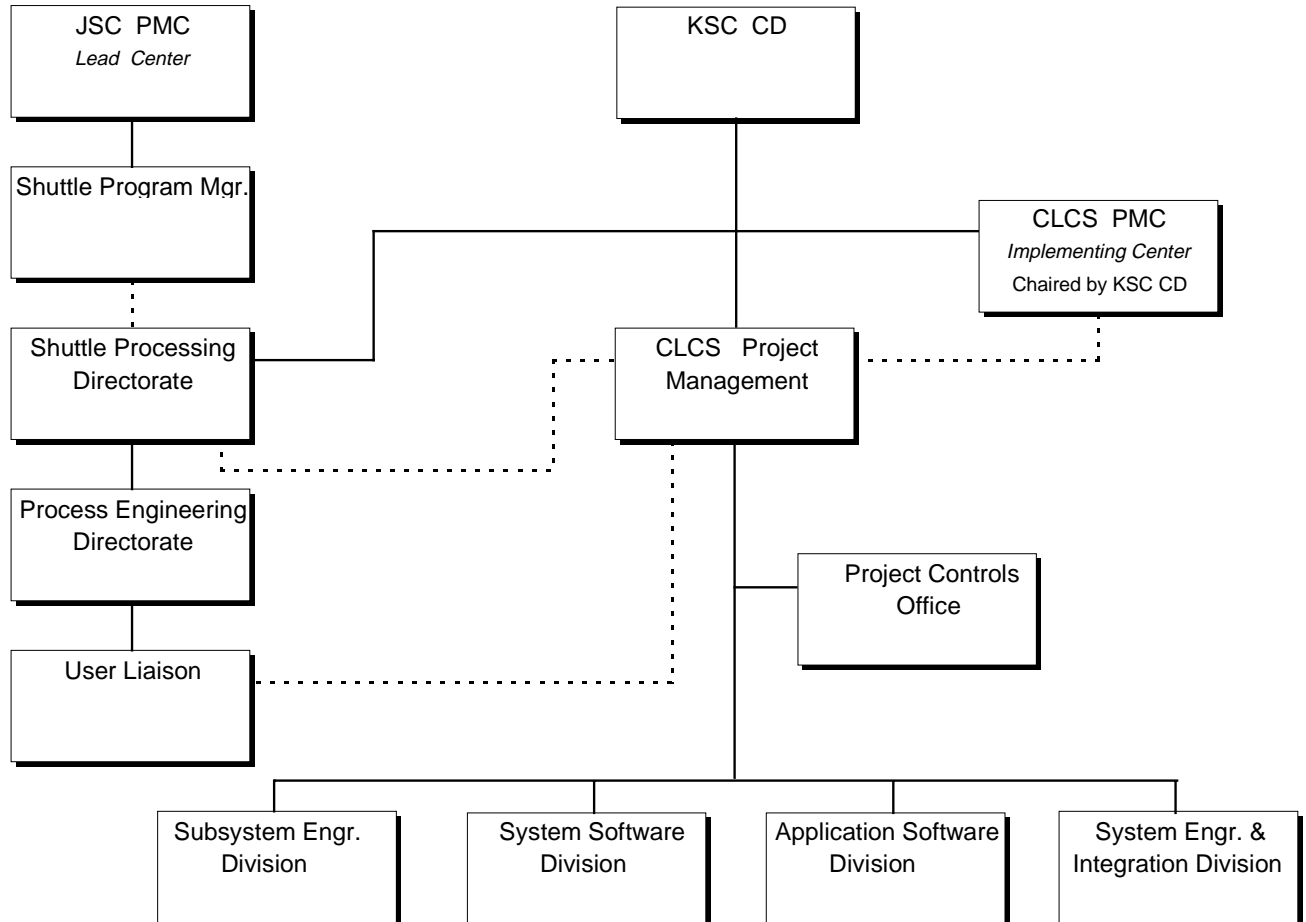


Figure 3-1 CLCS Organization Structure

3.1 SHUTTLE PROGRAM

The CLCS Project is funded by and operates under the auspices of the Space Shuttle Program (SSP). The SSP Manager, representing the Lead Center PMC, receives information and status on the CLCS Project on a periodic basis (quarterly or as requested by Program Manager) reflecting the technical and cost progress of the project. It is intended that the reporting of CLCS status and issues will be integrated into existing programmatic processes. The SSP Manager also approves Change Requests (CRs) for the project where new requirements have the potential to impact budget or schedule.

Funding for CLCS is carried as a Launch Support Equipment (LSE) line item under the responsibility of KSC's Director of Shuttle Processing.

3.2 CLCS PMC

The Implementing Center Program Management Council (PMC) consists of several members of KSC and Johnson Space Center (JSC) upper management who represent many dedicated years of experience in guiding and directing NASA in the achievement of its goals and mission. This organizational element is chartered to provide expertise and sound judgment on high level CLCS issues and will monitor the overall progress of the project relative to budget, schedule, and performance. They will also provide guidance, as required, so as to assure that CLCS fulfills the overall NASA mission. The CLCS PMC is chaired by KSC's Center Director. Other members are as follows: Deputy Director, KSC, Associate Director, Shuttle Upgrades (KSC), Chief, Information Office (KSC), Director of Shuttle Processing (KSC), Director of Engineering Development (KSC), Director of Logistics Operations (KSC), Director of Safety and Mission Assurance (KSC), Director of Payloads Processing (KSC), Director of Installation Operations (KSC), Chief Financial Officer (KSC), Director of Space Operations (JSC), and Project Manager, Checkout and Launch Control System Office (KSC).

3.3 PROJECT MANAGER/MANAGEMENT

The NASA Project Manager and Deputy Project Manager are responsible for the overall management of the CLCS Project and have accepted the responsibility to ensure that the CLCS Project is implemented in the most expeditious and cost-effective manner. They have the authority to direct project activities, approve principal project documents, contract and performance reports, control room transition strategy and priority, and content for upper level status briefings.

3.4 CIVIL SERVICE LABOR

The CLCS Project will be led and staffed with KSC Civil Service Labor from the Engineering Development (DE), Shuttle Processing (PH), Payload Processing (BB) and Safety and Mission Assurance (EC) Directorates. Project Management, planning, and engineering will be led by civil servants. Civil servants will do hands-on development in the hardware, software, system and facility design.

3.5 CONTRACTOR LABOR

The CLCS Project will require support from existing NASA contracts in the following areas:

- **SFOC** NAS9-20000 The Space Flight Operations Contract will provide Shuttle systems expertise, requirements, test and validation, facility modifications, training, application development and procurement support.
- **MSC** NAS9-18300 The Mission Support Contract will provide expertise on the JSC Mission Control Center (MCC) designs and potential reuse of government-owned designs and products selected from the MCC systems.
- **ESC** NAS10-11943 The Engineering Support Contract will provide development labor and expertise where sufficient resources and/or skills are not available within Civil Service.
- **PGOC** NAS10-11400 The Payload Ground Operations Contract will provide payloads systems expertise, requirements, test and validation, training, and application development support.
- **BOC** NAS10-12000 The Base Operations Contract will provide Complex Control Set systems expertise, requirements, test and validation, facility modifications, and training.

3.6 SOMO

The high-level architecture and functionality proposed for CLCS is similar to those architectures that exist or are being developed at other NASA and DOD Centers. In keeping with the charter for which the Space Operations Management Office (SOMO) was organized, to promote synergy and commonality across the development and operations of the different NASA Centers (thus reducing overall project costs), the CLCS Project envisions utilizing SOMO as a resource for information on CLCS-like Projects at those other Centers. In addition, CLCS Management and Engineering personnel will provide CLCS design and implementation information to the SOMO organization for retention in the SOMO Information Database and for analysis for commonality within the Agency.

In order to accomplish these technical communications, the CLCS Project will appoint a SOMO Liaison from the Project to interface with the designated SOMO representative(s) on a periodic basis. In addition, the designated SOMO representative(s) will be advised of and invited to the various Project Planning and Design Reviews where overall system Operations Concepts and architectural designs will be presented.

Based on SOMO recommendations, CLCS Project personnel will support attendance at other NASA Center design reviews to assist in the “search for synergy” across the other agency projects.

4. TECHNICAL AND SCHEDULE COMMITMENTS

CLCS is committed to providing a system with the flexibility required to allow shuttle processing to be achieved “the smart way”, taking advantage of what today’s technology has to offer. This includes providing multi-orbiter support from one control room, multi-system monitoring capability from one console, and local monitoring, command, and control of systems where operational efficiencies can be achieved. The project commits to reduce the number of engineers required on console for daily power-up operations by 50%. The project commits to reduce the amount of paper documentation required in the control rooms by 50%. The project commits to reduce O&M costs by 50% by increasing console Mean Time Between Failures (MTBF) from 70 hours to 10,000 hours, by decreasing the amount of hardware from 8 control rooms to 6, by using standard COTS software and reducing custom software from 12 million lines of code to 3.3 million, and by designing for system components to be returned to vendor while maintaining 100% daily support capability. The project is additionally committed to controlling development costs by leveraging commercial and government owned technology. Using industry standards will help minimize development time today, and support more rapid and economical system upgrades in the future thus enabling CLCS to support through the end of the Shuttle Program and to be easily adaptable to support future space vehicles.

The project is committed to achieving successful completion within five years ending in FY2001. The critical path for CLCS is the development, test, and certification of application software. Key milestones for application software development are part of an integrated package which composes each incremental delivery. Included in that package are additional milestones for facility modifications and transition. CLCS will be launch capable in December 2000. The following list identifies several of the milestones to which the CLCS project is committed:

Experimental Control Room Established	03/97
System Level Specifications Baselined	04/97
Ready to Support Super Light Weight Tanking Test	09/97
Console Enclosure Critical Design Review	09/97
Gateway H/W Critical Design Review	01/98
COTS Preliminary Design Review	05/98
Software Portability Demonstrated	05/98
SAIL (CLCS) available for software development	06/98
Demo of Auto Command and Control of Orbiter Power-up	09/98
Hypergolic Maintenance Facility ready for user acceptance	12/98
CDS Decommissioned	01/99
All OPF Application S/W Validated	03/00
CITE Fully Operational	03/00
Shuttle Element “No Impact” Assurance Review	06/00
First Complete CLCS Shuttle Processing Flow Begins	08/00
CLCS Launch Capable (1 st CLCS Control Room)	12/00
2 nd CLCS Control Room Fully Operational	04/01
3 rd CLCS Control Room and CCS Fully Operational	09/01

5. RESOURCE COMMITMENTS

The table below identifies the Project Cost Commitments for the CLCS Project. Although modifications to existing facilities will be required, the CLCS project has developed viable transition plans enabling the project to avoid the construction of any new facilities.

Project Cost Commitments (PCC), \$M for CLCS

Cost Commitment Category	FY97	FY98	FY99	FY00	FY01	FY02	Total
Contractor Labor	10.0	25.6	30.0	22.8	10.0	0.0	98.4
Materials (Non-labor)	9.8	12.4	17.3	10.6	4.1	0.0	54.2
Facility Mods (Non-labor)	.9	1.3	1.2	1.0	1.0	0.0	5.4
Travel & Training (Non-labor)	1.0	.7	.9	.9	.7	0.0	4.2
H/W & COTS S/W Maint. (Non-labor)	0	.4	1.7	2.9	4.2	0.0	9.2
Sub Total	21.7	40.4	51.1	38.2	20.0	0.0	171.4
Program Reserves (20%)	0.0	0.0	0.0	8.0	14.0	12.3	34.3
Total	21.7	40.4	51.1	46.2	34.0	12.3	205.7

CLCS is a NASA-managed re-engineering activity which will utilize both Civil Service and contractor resources. Figure 5-1 identifies the NASA and Contractor team proportions as planned.

	<u>FY97</u>	<u>FY98</u>	<u>FY99</u>	<u>FY00</u>	<u>FY01</u>	<u>FY02</u>	<u>Total</u>
Labor (FTE)	166	344	403	329	179		1421
Contractor	100	249	283	209	89		930
Civil Service	66	95	120	120	90		491
Contractor Cost	\$10.0	\$25.6	\$30.0	\$22.8	\$10.0		\$98.4
USA	3.2	7.6	11.5	11.8	8.1		42.2
LMSMS	4.8	12.3	12.0	5.4	0.5		35.0
I-NET	1.8	4.9	5.1	4.2	0.6		16.6
EG&G	0.1	0.4	0.7	0.7	0.4		2.3
MDS&DS	0.1	0.4	0.7	0.7	0.4		2.3
NASA Procurements	\$11.7	\$14.8	\$21.1	\$15.4	\$10.0		\$73.0
Total Cost (excl. CS)	\$21.7	\$40.4	\$51.1	\$38.2	\$20.0	\$0.0	\$171.4
APA	\$0.0	\$0.0	\$0.0	\$8.0	\$14.0	\$12.3	\$34.3
Costs Include:	Labor @100K/WY w/3% escalation LCC Facility Mods/CCMS Removal Installation & Activation SDC, SIM, & Models Deltas						OMI Rewrite Re-Certification RCVS Replacement Training, Travel

Funding: Shuttle Launch Site Equipment Upgrades (UPN 260)

Figure 5-1 CLCS Resource Requirements

6. OPERATIONS COSTS AND COST SAVINGS

The table below contains data from the CLCS Life Cycle Cost Analysis. Allowing 3% escalation against current O&M costs with no additional allowance for costs due to increasing obsolescence, CLCS projects a cost savings approximating 50% (46%) by FY03.

Extract from Life-Cycle Cost Analysis	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08
CLCS DEVELOPMENT LABOR (\$K)	\$10,000	\$25,600	\$30,000	\$22,800	\$10,000							
CLCS equipment (\$K)	\$6,515	\$10,648	\$14,486	\$9,785	\$4,120							
CLCS COTS S/W(\$K)	\$1,000	\$1,000	\$1,000		\$0	\$0						
CLCS hardware maint (\$K)	\$0	\$259	\$1,410	\$2,505	\$3,698	\$3,809	\$3,923	\$4,041	\$4,162	\$4,287	\$4,416	\$4,548
CLCS software maint (\$K)	\$0	\$150	\$300	\$450	\$450	\$464	\$477	\$492	\$506	\$522	\$537	\$553
training	\$964	\$553	\$829	\$829	\$553	\$100	\$100	\$100	\$100	\$100	\$100	\$100
travel	\$100	\$100	\$100	\$100	\$100	\$25	\$25	\$25	\$25	\$25	\$25	\$25
rcvs/sdc/sim deltas	\$0	\$800	\$1,800	\$800	\$0							
facility mods	\$900	\$1,300	\$1,200	\$1,000	\$1,000	\$200	\$200	\$200	\$200	\$200	\$200	\$200
fy96 RO&dev eng	\$2,230											
(totals match CLCS ROM thru 01)	\$21,709	\$40,410	\$51,125	\$38,269	\$19,921							
SDC-BASIC DEV. LABOR(260)	\$1,125	\$927										
SDC-BASIC DEV. LABOR(250)	\$1,575	\$1,545	\$2,387	\$2,459	\$1,182							
SDC-BASIC DEV NON-LABOR	\$1,696	\$3,205	\$5,957	\$2,863	\$4,314							
(totals match SDC POP thru 01)	\$2,821	\$4,132	\$5,957	\$2,863	\$4,314							
SIM-BASIC DEV. LABOR												
SIM-BASIC DEV. NON-LABOR	\$241	\$485	\$1,186	\$1,280	\$793	\$428	\$0	\$0	\$0	\$0	\$0	
SDC/Sim HW/OS Maintenance						\$2,100	\$2,100	\$2,100	\$2,100	\$2,100	\$2,100	\$2,100
Misc labor (Drafting, Logistics,etc.)						\$1,034	\$888	\$915	\$942	\$971	\$1,000	\$1,030
CLCS Maintenance labor						\$3,377	\$3,478	\$3,582	\$3,690	\$3,800	\$3,914	\$4,032
CLCS Sustaining labor						\$4,773	\$3,152	\$3,247	\$3,344	\$3,444	\$3,548	\$3,654
						\$2,448	\$2,521	\$2,597	\$2,675	\$2,755	\$2,838	\$2,923
CLCS Operations Labor						\$3,391	\$3,493	\$3,597	\$3,705	\$3,816	\$3,931	\$4,049
SDC/Sim Maintenance labor	\$150	\$541	\$1,273	\$1,475	\$1,519	\$1,565	\$1,612	\$1,660	\$1,710	\$1,761	\$1,814	\$1,869
SDC/Sim Sustaining/upgrade labor		\$0	\$716	\$738	\$760	\$1,958	\$2,016	\$2,077	\$2,139	\$2,203	\$2,269	\$2,338
SDC/Sim Operations Labor				\$820	\$844	\$869	\$896	\$922	\$950	\$979	\$1,008	\$1,038
						\$7,700	\$8,380	\$8,565	\$8,756	\$8,953	\$9,156	\$9,364
total non labor	\$13,646	\$18,500	\$28,268	\$19,612	\$15,028	\$14,825	\$15,206	\$15,523	\$15,850	\$16,187	\$16,534	\$16,891
total labor	\$12,850	\$28,613	\$34,376	\$28,291	\$14,305	\$19,415	\$18,056	\$18,598	\$19,156	\$19,731	\$20,323	\$20,932
	\$26,496	\$47,113	\$62,644	\$47,903	\$29,333	\$34,240	\$33,262	\$34,121	\$35,006	\$35,917	\$36,856	\$37,823
Maintenance	\$150	\$541	\$1,273	\$1,475	\$1,519	\$11,314	\$11,590	\$11,875	\$12,168	\$12,470	\$12,782	\$13,102
Operations	\$0	\$0	\$0	\$820	\$844	\$4,260	\$4,388	\$4,520	\$4,655	\$4,795	\$4,939	\$5,087
Sustaining	\$0	\$0	\$716	\$738	\$760	\$7,765	\$6,057	\$6,239	\$6,426	\$6,619	\$6,817	\$7,022
	\$0	\$0	\$0	\$0	\$0	\$10,473	\$11,226	\$11,487	\$11,756	\$12,033	\$12,319	\$12,612
Development/Deploy	\$26,346	\$46,572	\$60,655	\$44,871	\$26,210	\$428						
total	\$26,496	\$47,113	\$62,644	\$47,903	\$29,333	\$34,240	\$33,262	\$34,121	\$35,006	\$35,917	\$36,856	\$37,823

7. PROJECT RISKS (FROM CLCS RISK MANAGEMENT PLAN)

The risk management process is designed to ensure the early exposure and identification of risk so that favorable mitigation plans can be developed before the identified risk can impact the project. The methodology to continually track progress especially in areas where identified risks are present is essential for effective risk management. This allows for timely execution of mitigation plans, which is the tool for monitoring the selected alternatives in the risk mitigation process. This approach supports sound project management decisions and promotes open discussion among our teammates.

Although tailored and optimized for application to the CLCS project, the CLCS risk management process in itself is not unique. What will determine whether the CLCS Risk Management Plan is effective or not depends on the foresight to effectively choose and use the correct tools in the process. The CLCS project team offers proven ability to manage project risk through both past performance and its current experience managing development projects. Legacy processes and procedures successfully applied on these projects provide a proven baseline for risk management on CLCS.

7.1 INTRODUCTION

The intent of the CLCS Risk Management Plan is to provide a disciplined and documented approach to risk management throughout the project life cycle and to support management decision making in regards to risk assessments (i.e., taking into account cost, schedule, performance, and safety concerns).

7.2 RISK MANAGEMENT APPROACH

7.2.1 Risk Management Philosophy/Overview

For some, risk is what you take, for others, risk is what you avoid. For CLCS to be successful in its goals of finding ways to be better, faster, cheaper, risk has to become a partner or resource instead of an enemy. As CLCS challenges the way we have done things for decades, processes that are part of our cultural existence, CLCS will use risk as a tool through effective identification and risk management.

7.2.2 Risk Management Responsibilities

The CLCS Project Manager is ultimately responsible for managing risk for the project. The entire project team will support the Project Manager throughout the risk management process to assure all risks are identified, analyzed, mitigated, and tracked. Additionally, the CLCS PMC (see section 3.2) will be a critical resource for the risk management process.

7.2.3 The Risk Management Mindset

Early identification and disclosure of risk and the development of mitigation plans is essential to an effective risk management process. The mature CLCS process will continually track progress against our risk mitigation plans and monitor the project to identify

new risks, support sound project management decisions for the overall project for each task, and ensure that there are no surprises throughout the life of the contract.

CLCS risk management is tightly coupled with the product development process. As an integral part of this process, CLCS will promote this mindset on the project through open discussions between all members. These discussions will enable us to identify risks early and to effect changes in our project that will most effectively mitigate these risks. Discussions include informal discussions (product development team activities, memos, emails, and ad-hoc meetings) and formal, scheduled meetings (project status reviews, risk review board meetings, management meetings). Such communications enable project management to remain close to and candid with the team members throughout the life of the project. These interfaces also provide a mechanism to review and use lessons learned in the risk management process by planning for similar risks before they arise, allowing CLCS to remain proactive instead of reactive. Figure 7.2.3-1 illustrates this approach to collective communication.



Figure 7.2.3-1 Risk Management Mindset

7.3 RISK MANAGEMENT METHODOLOGIES, PROCESSES, AND TOOLS

Managing risk effectively involves using the correct tools and processes during risk planning. Figure 7.3-1 illustrates the relationship of the activities associated with successful risk management.

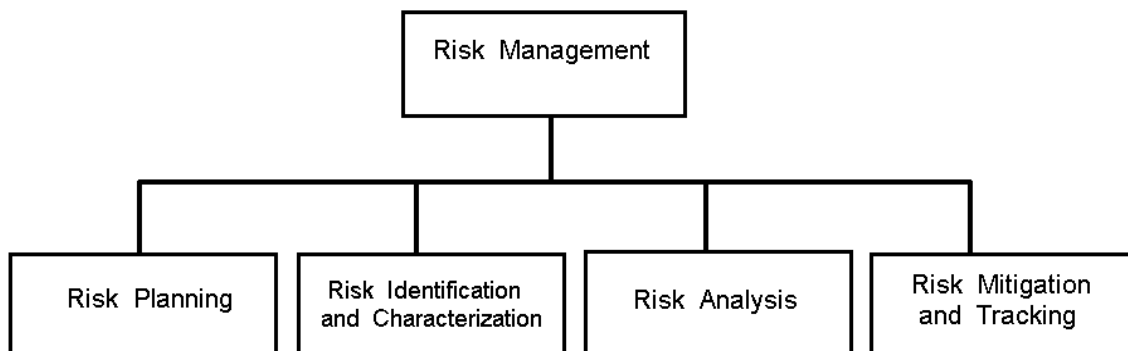


Figure 7.3-1 Structure of Risk Management

7.3.1 Risk Identification and Characterization

CLCS will use a variety of techniques for risk identification and characterization. The thoroughness in which this is accomplished is an important factor to the success of CLCS's risk management program.

7.3.1.1 Expert Interviews

Expert interviews will be a major source of insight and information in the identification and characterization of risk. Being that CLCS is the replacement for the existing Launch Processing System, numerous system experts are available for consultation. As involvement from the user community is critical to the success of the CLCS project, many of these experts are full time members of the CLCS team.

7.3.1.2 Independent Assessments

CLCS will use independent assessments in the identification and characterization of risk in three forms: 1) review of project documentation, 2) evaluation of the WBS for completeness and consistency, and 3) independent cost estimates.

7.3.1.3 Lessons Learned

A thorough review of similar government projects has been conducted in preparation for initiating the CLCS Project. Lessons learned has been and will continue to be one of the more valuable tools for identifying and characterizing risk for CLCS.

7.3.1.4 Risk Templates

Previously developed risk templates (e.g. DoD 4245.7-M) will be evaluated for their potential application in the identification of risk in the CLCS risk management process.

7.3.1.5 FMECAs and Fault Trees

Specialized techniques for safety (and/or hazard) will be reviewed for their potential contributions in the identification and characterization of risk for the CLCS project. Where practical and beneficial, these techniques will be utilized to focus on the system design and to categorize each potential failure mode according to severity.

7.3.2 Risk Analysis

A variety of techniques for risk analysis will be employed in the CLCS risk management process.

7.3.2.1 Decision Analysis

Decision analysis is a technique to help the decision process when dealing with a complex set of uncertainties. CLCS will use this approach when applicable to divide-and-conquer, decomposing complex issues into simpler ones which can then be treated separately. Decision trees will be utilized to illustrate graphical images of the complex problems under going analysis.

7.3.2.2 Probabilistic Network Schedules

Probabilistic network schedules, such as PERT (Program Evaluation and Review Technique) will be a major tool used by CLCS in risk analysis. This tool will allow project management to input minimum, maximum, and most likely duration for each activity which can then be used to determine the probability that the project or a particular task can be completed by a given date. This method of analysis is also valuable in the determination of critical path.

7.3.2.3 Probabilistic Cost and Effectiveness Models

Probabilistic cost and effectiveness models will be used to provide insight into the probabilistic project cost and effectiveness.

7.3.3 Risk Mitigation and Tracking

Typically, four responses to a specific risk are usually available: 1) do nothing and accept the risk, 2) share the risk with a co-participant, 3) take preventative action to avoid or reduce the risk, and 4) plan for contingent action. CLCS will select the appropriate response based on criticality and priorities of the identified risk element.

7.3.3.1 Risk Mitigation by Type

7.3.3.1.1 Technical Risk

Typical technical risk mitigation actions will likely include additional system testing, designing in redundancy, and building a full engineering model.

7.3.3.1.2 Cost Risk

Cost risk mitigation actions will typically include using Commercial-Off-the-Shelf (COTS) hardware and providing sufficient funding during the early phases of the project's life-cycle.

7.3.3.1.3 Schedule/Performance

For CLCS, the mitigation of schedule risks are less systematic and will therefore require more attention. It is often extremely difficult to accurately assess "percentage complete" of a task. This affords the opportunity to gain insight too late in the process, increasing the probability of late deliveries and/or system capability impacts.

7.3.3.2 Risk Mitigation and Tracking Tools

7.3.3.2.1 Watchlists and Milestones

CLCS will use watchlists to track identified risks. These lists will identify triggering events or missed milestones, the related areas of impact, and the risk mitigation strategy.

7.3.3.2.2 Contingency and Descope Planning

CLCS will develop contingency and descope plans in conjunction with specific items identified on the watchlists. These plans will focus on developing work-arounds to be activated upon a triggering event. Mitigation planning may involve beginning the work-around when a triggering event occurs or could also involve early start of parallel efforts which will provide a return only if the triggering event occurs.

7.3.3.2.3 Cost, Schedule, and Technical Performance Tracking

Cost & Schedule Control Systems & Technical Performance Measure Tracking will serve as valuable tools for tracking risk of these key project parameters. The CLCS Performance Measurement Plan will be used to assess cost, schedule, and technical performance beginning with the Redstone delivery. The CLCS Performance Measurement Plan tool is being developed with guidelines which will enable the preparation of a brief but accurate report to provide insight to the overall performance of the project. In general, cost, and schedule performance will be measured and finally cost compared against schedule.

As technical progress provides further insight, Project Plan Reviews will be conducted periodically to assess previously unidentified systems needs against the baseline system requirements.

7.4 SIGNIFICANT IDENTIFIED RISKS

The following is a list of the significant risks currently identified for the CLCS Project. The risks identified in this list and the assessment of each will be evaluated periodically and revised as progress and insight are obtained.

7.4.1 Cost

Cost has been identified as a risk to CLCS. The majority of the hardware acquisitions are planned to be Commercial-off-the-Shelf products which mitigates the cost risk element in regards to hardware.

CLCS is a five year extensive software effort, and software development is the major portion of the 1400 + labor-years effort. Keeping the project on schedule will in itself mitigate cost risks for labor (see Section 7.4.2). Incremental deliveries will add significant insight as to the achievement of “real” milestones and therefore attribute to the mitigation of this risk element. The basis of estimate for CLCS costs have been reviewed by program personnel from JSC and deemed to be adequate. In addition, the Shuttle program has established a reserve for the project of 20%.

7.4.2 Schedule

With an aggressive, success driven, product oriented, five-year schedule, CLCS is in full realization of schedule risk. The CLCS Project has adopted the concept of incremental deliveries to help in the mitigation of technical and schedule risk. By breaking the project up into smaller pieces, the incremental approach provides an accurate insight into overall project status and ensures that the system is delivered.

Having in-depth involvement from the user community throughout the project’s life-cycle is another key element to the project’s success as this addition to the project team allows for early detection of latent flaws and quick turnaround of system fixes.

The CLCS PMC, chaired by the KSC Center Director, has made assuring the availability of KSC resources its foremost priority. This management commitment has reduced

supportability risk in areas where support, facilities, and communications modifications are the predominate threats to the schedule.

The project team is identifying requirements early and obtaining commitments from supporting organizations to mitigate this risk.

There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established.

7.4.3 Technical

CLCS is a complex real time command and control environment in support of critical, high energy systems. Technical risk associated with custom software development is mitigated by the availability of expertise on the existing LPS, the use of COTS and industry standards, and the leveraging of technology from MCC and other similar checkout and control systems.

Therefore, CLCS is an application of state-of-the-art technology and is not driving the formulation of new technology. With the advantages of the incremental delivery concept and the dedicated involvement from the user community as discussed in section 7.4.2, technical risk is considered low.

7.4.4 Capture of System Requirements

There are 12 million lines of code in 3800 applications programs to be re-engineered and totally rewritten in a new language. There will be a tendency on the part of the user community to enhance and expand system requirements. Certain enhancements will be allowed if the benefits are substantial and the work can be accomplished so as to not impact the CLCS overall delivery schedule. A CLCS requirements control board will be established to approve changes to baseline requirements to control and mitigate this risk internally. Programmatically, existing requirements control boards will be utilized to the maximum extent possible. The requirements control board, utilizing its corporate knowledge of these existing application requirements, will approve changes to baseline requirements and thereby control and mitigate this risk.

Being that CLCS is the replacement for the existing Launch Processing System, numerous civil service and contractor system experts are available for consultation in both areas of operations and system requirements. These experts from the operations and user communities are valuable assets to the CLCS team as the team works diligently to challenge and separate real requirements from decades of cultural influences. The user community is responsible for developing, approving, and performing the test plans for the verification, validation, and certification of CLCS. This involvement will provide early user review of the real system and contribute significantly in the mitigation of this risk element.

7.4.5 Funding - Adequacy

The basis of estimate for CLCS costs have been reviewed by program personnel from JSC and deemed to be adequate. An additional 20% reserve has been established by the Shuttle program.

7.4.6 Funding and Project Goals - De-scope Plan

Availability of adequate funding is a risk to any project. There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established. CLCS is the replacement for the existing LPS. Requirements for a Launch Processing System that meet safety and mission requirements and standards have evolved from twenty years of operating the existing LPS. De-scoping requirements as a result of potential budget reductions will result in a system that will fail to meet these minimum requirements and therefore will not enable the Program to decommission the existing LPS. CLCS does not plan to incorporate new requirements, but due to capabilities inherent with new technology, CLCS does intend to support new features which are anticipated to provide additional opportunities for achieving cost saving in its operation and use. Therefore, this De-scope Plan does not address reducing or eliminating requirements as specified for a manned space flight program. This plan will define “usable capability” that can benefit the Shuttle Program if CLCS project funding is withdrawn prior to full implementation of the Project’s plans and goals.

If funding were withdrawn following:

First Qtr - FY98

Total CLCS funded project expenditures to date would be approximately \$30 million and 90 Civil Service Full Time Equivalent (FTE) Work Years.

LCC-2 Multi-flow - The CLCS transition plan requires the existing Control Room 2 (LCC-2) to be implemented with additional LPS hardware to support multiple non-integrated flows. By this time, the existing Control Room 4 (LCC-4) would have been decommissioned and mid-way through renovation for CLCS. Although somewhat limited, achieving multi-flow capability in LCC-2 would leave LPS with its current ability to support four orbiters in-flow. Supporting four flow from three control rooms would allow for some O&M cost savings.

Second Qtr - FY98

Total CLCS funded project expenditures to date would be approximately \$37 million and 115 Civil Service FTE Work Years.

PCGOAL and Consolidated Data - CLCS would have completed the consolidation of data from numerous satellite systems (e.g. meteorological data, Ground Measurement System (GMS), etc.) that have evolved in an attempt to respond to user requirements that due to lack of capability, could not be implemented on the existing LPS. Refinement and maturing of PCGOAL would have also been accomplished. Some cost savings associated with the O&M of these systems could be realized.

First Qtr - FY99

Total CLCS funded project expenditures to date would be approximately \$75 million and 190 Civil Service FTE Work Years.

SDC - CLCS would have completed and implemented the SDC enabling the transition from the CDS to SDC allowing CDS to be decommissioned. This would include the re-host of the Shuttle Ground Operations Simulation (SGOS). Decommissioning CDS would avoid the millennium problem associated with the CDS mainframes and allow for some cost savings associated with the O&M of the existing CDS.

HMF - CLCS would have replaced hardware and re-engineered software to bring the Hypergol Maintenance Facility (HMF) ready for user acceptance. Following user acceptance, the HMF would become operational and the existing HMF LPS set could be decommissioned allowing for some cost savings associated with the O&M of the existing HMF LPS set.

Important Milestone - Reviews will be held in May, 1998 in preparation for procuring hardware for OCR-1, the first major CLCS hardware buy. Being that by the end of first quarter of 1999, OCR-1 will not have progressed to the point of providing any usable capability to the program. If it were known that funding was to be terminated, it would be advisable to avoid this procurement activity. Therefore, early knowledge of project funding termination could save \$5 - 7 million.

Second Qtr - FY00

Total CLCS funded project expenditures to date would be approximately \$135 million and 340 Civil Service FTE Work Years.

OCR-1 - CLCS would have completed all facility modifications associated with transitioning LPS LCC-4 to CLCS OCR-1 including the procurement and installation of all new enclosures and hardware. OPF system and application software would have been completed and validated enabling CLCS to fully support OPF related processing following an appropriate Operational Readiness Review (ORR). Measurable O&M costs savings associated with the use of OCR-1 could be achieved.

CITE - CLCS would have completed all facility modifications associated with transitioning the LPS Cargo Integrated Test Equipment (CITE) to CLCS CITE including the procurement and installation of all new enclosures and hardware. CITE system and

application software would have been completed and validated enabling CLCS to fully support the first CLCS payload flow, leading to the decommissioning of the existing LPS CITE. Measurable O&M costs savings associated with the use of the CLCS CITE could be achieved.

Fourth Qtr - FY00 Total CLCS funded project expenditures to date would be approximately \$160 million and 400 Civil Service FTE Work Years.

OCR-1 - Implementation of the first fully operational and launch supportable CLCS control room will have been completed. This would allow one of the two existing launch supportable LPS control rooms to be decommissioned enabling significant O&M cost savings in the operation of OCR-1 to be achieved.

If funding was re-phased:

Re-phasing of the CLCS project by the shift of funding to out years, would extend the duration of the project. In general, the project could be fully implemented if re-phased but would require additional funding, depending on the degree of re-phasing. In addition, re-phasing brings other issues to the surface; i.e. major re-phasing early in the project could impact the development strategy to use the MSC contractor to the extent as currently planned, as this contract will terminate in December, 1999.

In either account, the current LPS suffers from reliability and obsolescence problems which bring the potential for additional rising costs for a system whose O&M costs are already significantly high (\$50 million/year). Based on the current launch rate, CLCS has committed to reducing these costs by 50%. Failure to complete the project will significantly affect projected cost savings and still leave obsolescence and reliability issues associated with the current LPS unresolved.

Additionally, LPS has serious expansion limitations, limitations which could preclude the ability for LPS to support Shuttle upgrades. CLCS is a highly flexible system which brings the capability to support these upgrades as well as the ability to support future launch vehicles.

7.4.7 Human Resources - Availability

Key to CLCS success is having the right human resources involved throughout the project's life-cycle. Although civil service and contractors have many experts available to provide valuable insight to the project, the aggressive, success driven CLCS schedule depends on the ability to gain other support in specialty areas. There is also risk that as KSC reduces its work force that there is be an insufficient number of Civil Servants to support CLCS and

support KSC's mission. With the CLCS PMC committed to assuring the availability of KSC resources as its foremost priority, this risk is significantly reduced.

Additionally, long term funding provides the job security required to obtain many of the required resources that have been or are to be contracted. There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established.

7.4.8 Human Resources - Control / Influence

In addition to Civil Service personnel, the CLCS Project depends on multiple contractors as listed in Section 3.5. CLCS primarily uses SFOC (JSC), MSC (JSC), and ESC (KSC). As these contracts have primary missions and goals other than CLCS, there is risk that CLCS will be unable to be of sufficient influence to positively affect contractor performance. Specific completion form deliverables have been defined and assigned to each contractor to mitigate this risk. A procedure has been established to input performance criteria specific to each contractor as well as evaluation of the contractor accordingly.

7.4.9 Impact to Manifest

In parallel with the attempt to minimize costs for the project, CLCS intends to reuse the existing LPS facilities in the implementation of CLCS. Although this approach offers the benefit of significant cost savings, the down side is the potential for impact to the on-going Shuttle processing and launch manifest. The CLCS transition plan depends on the cooperation of the processing and launch team for its success. As vital members of the processing and launch team are actively involved in CLCS's life-cycle, the CLCS team is very optimistic that transition from LPS to CLCS, while reusing the existing LPS facilities, can effectively be accomplished with minimal or no impact.

7.4.10 Commitments

The project has committed to achieving successful completion within five years ending in FY2001. The critical path for CLCS is the development, test, and certification of application software. Key milestones for application software development are part of an integrated package which composes each incremental delivery. Included in that package are additional milestones for facility modifications and transition.

The project has also committed to reducing O&M costs by 50% by increasing console MTBF from 70 hours to 10,000 hours, by decreasing the amount of hardware from 8 control rooms to 6, by using standard COTS software and reducing custom software from 12 million lines of code to 3.3 million, and by designing for system components to be returned to vendor while maintaining 100% daily support capability.

Additional commitments are identified in the Program Commitment Agreement (84K0007). CLCS will establish measurements to monitor the progress towards achieving the commitments described herein. Project management, as well as the CLCS PMC, will closely monitor this risk element.

8. EXTERNAL AND INTERNAL AGREEMENTS/DEPENDENCIES

8.1 INTERNAL

CLCS Project Management and their management have additionally defined the Project's commitments in the Program Commitment Agreement (PCA) for CLCS. After initial baselining of the PCA, the monitoring of progress against the PCA will be delegated to the Lead Center PMC.

The CLCS is handled completely within the Shuttle Program. The high-level architecture and functionality proposed for CLCS is similar to those architectures that exist or are being developed at other NASA and DOD Centers. In keeping with the charter for which SOMO was organized, to promote synergy and commonality across the development and operations of the different NASA Centers (thus reducing overall project costs), the CLCS Project envisions utilizing SOMO as a resource for information on CLCS-like Projects at those other Centers. In addition, CLCS Management and Engineering personnel will provide CLCS design and implementation information to the SOMO organization for retention in the SOMO Information Database and for analysis for commonality within the Agency.

Prior to the first complete CLCS Shuttle processing flow, a review will be conducted to provide the assurance that CLCS has no impact to flight elements.

8.2 EXTERNAL AGREEMENTS.

None.

9. PCD ACTIVITIES LOG

Date	Event	Change	Addendum	Proj. Mng. Signature	Space OPS Directors Signature

10. PERFORMANCE MEASUREMENT REQUIREMENTS

CLCS will use the its Performance Measurement Plan (84K00010) to assess its progress and accomplishments in regards to cost, schedule, and technical performance and will include analysis in the form of earned-value. Cost and schedule data will be analyzed against two sets of planning data. 1) In-depth project planning was performed by the Initial 60-Day Team. The resulting data has been used to establish the project's cost and schedule baseline and which will be updated as appropriate. 2) The system being developed by this project will evolve from incremental deliveries. These deliveries are intended be made approximately one every six months over the five year period, totaling 10 deliveries. Each

delivery will have its own mini design, development, and implementation cycle. During the “kick-off” of each delivery cycle, detailed delivery planning will be performed, updating cost and schedule plans accordingly. This revised plan will serve as updates to the baseline for cost and schedule performance analysis.

PROJECT MANAGEMENT AND CONTROLS

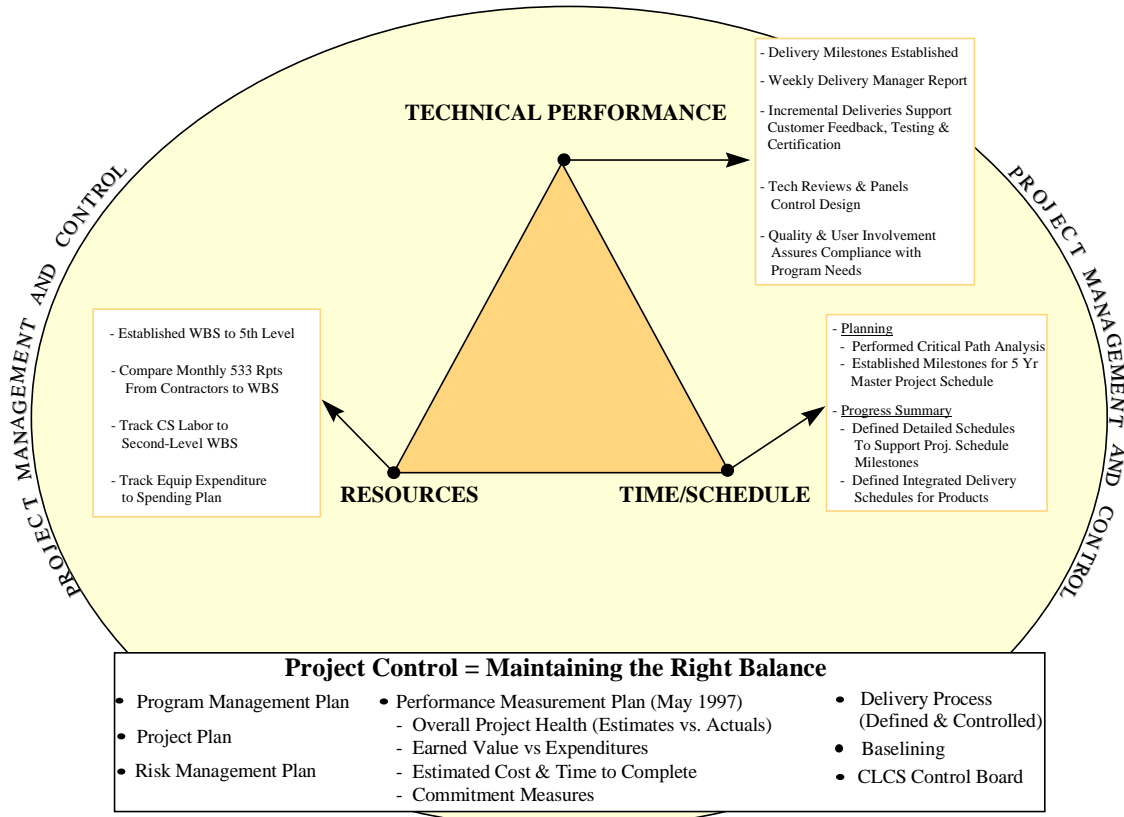


Figure 10-1 CLCS Management and Controls

Figure 10-1 illustrates the relationship between technical performance, resources, time/schedule, and management and controls. Additionally, this figure lists the major tools to be used in order to maintain the correct balance among these elements. Beginning with the second delivery, September 1997, the CLCS Performance Measurement Plan will be used to assess cost, schedule, and technical performance. The Performance Measurement Plan will also identify and establish measurements to monitor the progress towards achieving the commitments described in the Program Commitment Agreement (84K00007) as well as this document. Any significant change to the project’s cost, schedule or technical content will require an update to the PCA and this PCD. The CLCS PMC will judge the significance of changes of the project’s key parameters.

END